C L A I M S

1. An estimation system for estimating an object state, characterized by comprising:

image input means for inputting an input image containing an object whose state is to be estimated, the state being at least one of a position and posture;

3D shape data storage means for storing 3D shape data of the object;

comparison image generation means for generating, as a comparison image, an image containing the object in a predetermined state by using the 3D shape data stored in said 3D shape data storage means;

image positional relationship detection means for detecting, for each sub-region having a predetermined size in the image, a positional relationship between the input image and the comparison image generated by said comparison image generation means;

correction amount calculation means for calculating a correction amount of the object state in the comparison image by using the positional relationship detected by said image positional relationship detection means; and

state correction means for correcting the object state set in comparison image generation by said comparison image generation means by using the correction amount obtained by said correction amount

calculation means, thereby calculating a new object state.

2. An estimation system for estimating an object state according to claim 1, characterized by further comprising state determination means for determining on the basis of the correction amount obtained by said correction amount calculation means whether the object state set by said comparison image generation means is appropriate,

wherein when it is determined that the object state is appropriate, the object state set by said comparison image generation means is output as an estimation value, and

when it is determined that the object state is not appropriate, estimation processing including the comparison image generation processing by said comparison image generation means, the positional relationship detection processing by said image positional relationship detection means, and the correction amount calculation processing by said correction amount calculation means is executed again by setting the new object state calculated by said state correction means to the predetermined state.

3. An estimation system for estimating an object state according to claim 2, characterized in that said state determination means determines that the object state is appropriate when the correction amount

obtained by said correction amount calculation means is smaller than a predetermined amount, and determines that the object state is not appropriate when the correction amount is not smaller than the predetermined amount.

4. An estimation system for estimating an object state according to claim 2, characterized by further comprising:

first similarity calculation means for calculating a first similarity between the comparison image and the input image after the estimation processing is executed again; and

second similarity calculation means for calculating a second similarity between the comparison image and the input image before the estimation processing is executed again,

wherein said state determination means compares the first similarity with the second similarity, determines that the object state is not appropriate when the first similarity is higher than the second similarity, and determines that the object state is appropriate when the first similarity is not higher than the second similarity.

5. An estimation system for estimating an object state according to claim 1, wherein

said image input means comprises means for inputting a moving image containing an object, and

said image positional relationship detection

means uses a latest frame image of the moving image as the input image.

6. An estimation system for estimating an object state according to claim 1, characterized in that said comparison image generation means comprises:

means for reproducing a luminance value of an object surface, which changes depending on an illumination condition; and

means for generating the comparison image under an illumination condition close to that for the input image by using the reproduced luminance value.

7. An estimation system for estimating an object state according to claim 6, characterized by further comprising illumination base image group storage means for storing an illumination base image group representing a variation in luminance of the object surface depending on the illumination condition,

wherein said comparison image generation means reproduces the luminance value of the object surface by using the illumination base image group stored in said illumination base image group storage means.

8. An estimation system for estimating an object state according to claim 7, characterized by further comprising:

3D shape measuring means for measuring the 3D shape data of the object and reflectance data of the object surface; and

illumination base calculation means for calculating an illumination base image representing the variation in luminance of the object surface depending on the illumination condition by using the 3D shape data and the reflectance data of the object surface which are measured by said 3D shape measuring means.

9. An estimation system for estimating an object state according to claim 8, characterized in that

said illumination base calculation means calculates a vector group representing the luminance value of each point of the 3D shape data under a plurality of illumination conditions, obtains a base vector group in descending order of eigenvalues by principal component analysis of the vector group, and outputs the base vector group as the illumination base image group, and

said comparison image generation means obtains, by using the 3D shape data of the object, a correspondence between each point of the 3D shape data of the object and a pixel of the image with the object being in an estimation value at current time, generates, by using the correspondence, an image illumination base group in which the illumination base image group is projected to the image with the object being in the estimation value, and generates, as the comparison image, an image nearest to the input image by linear connection of the image illumination base group.

10. An estimation system for estimating an object state according to claim 1, characterized in that said correction amount calculation means calculates, as the correction amount, a 3D motion of the object which causes a moving amount of an object part corresponding to each sub-region in the comparison image to be near to an image displacement distribution by using the 3D shape data of the object and the image displacement distribution representing the positional relationship between the comparison image and the input image for each sub-region.

11. An estimation system for estimating an object state according to claim 1, characterized by further comprising feature extraction means for extracting an image feature amount of each of the input image and comparison image on the basis of luminance values of the input image and the comparison image generated by said comparison image generation means,

wherein said image positional relationship detection means detects the positional relationship between the input image and the comparison image for each sub-region on the basis of the image feature amount extracted by said feature extraction means.

12. An estimation method of estimating an object state, characterized by comprising the steps of:

inputting an input image containing an object whose state is to be estimated, the state being at least

one of a position and posture;

generating, as a comparison image, an image containing the object in a predetermined state by using 3D shape data of the object;

detecting a positional relationship between the comparison image and the input image for each sub-region having a predetermined size in the image;

calculating a correction amount of the object state in the comparison image by using the detected positional relationship; and

correcting the object state set in comparison image generation by using the calculated correction amount, thereby calculating a new object state.

13. An estimation method of estimating an object state according to claim 12, characterized by further comprising the steps of:

determining on the basis of the calculated correction amount whether the object state set in comparison image generation is appropriate; and

outputting the object state set in comparison image generation as an estimation value when it is determined that the object state is appropriate,

wherein when it is determined that the object state is not appropriate, estimation processing including the step of generating the comparison image, the step of detecting the positional relationship, and the step of calculating the correction amount is

executed again by setting the calculated new object state to the predetermined state.

14. An estimation method of estimating an object state according to claim 13, characterized in that in the determination step, it is determined that the object state is appropriate when the correction amount is smaller than a predetermined amount, and it is determined that the object state is not appropriate when the correction amount is not smaller than the predetermined amount.

15. An estimation method of estimating an object state according to claim 13, characterized by further comprising the steps of:

calculating a first similarity between the comparison image and the input image after the estimation processing is executed again; and

calculating a second similarity between the comparison image and the input image before the estimation processing is executed again,

wherein in the determination step, the first similarity is compared with the second similarity, it is determined that the object state is not appropriate when the first similarity is higher than the second similarity, and it is determined that the object state is appropriate when the first similarity is not higher than the second similarity.

16. An estimation method of estimating an

object state according to claim 12, wherein

in the step of inputting the image, a moving image containing an object is input, and

in the step of detecting the positional relationship, a latest frame image of the moving image is used as the input image.

17. An estimation method of estimating an object state according to claim 12, characterized in that the step of generating the comparison image comprises the steps of:

reproducing a luminance value of an object surface, which changes depending on an illumination condition; and

generating the comparison image under an illumination condition close to that for the input image by using the reproduced luminance value.

18. An estimation method of estimating an object state according to claim 17, characterized in that in the step of generating the comparison image, the luminance value of the object surface is reproduced by using an illumination base image group representing a variation in luminance of the object surface depending on the illumination condition.

19. An estimation method of estimating an object state according to claim 18, characterized by further comprising the steps of:

measuring the 3D shape data of the object and

reflectance data of the object surface; and

calculating an illumination base image representing the variation in luminance of the object surface depending on the illumination condition by using the 3D shape data and the reflectance data of the object surface.

20. An estimation method of estimating an object state according to claim 19, characterized in that

in the step of calculating the illumination base image, a vector group representing the luminance value of each point of the 3D shape data under a plurality of illumination conditions is calculated, a base vector group is obtained in descending order of eigenvalues by principal component analysis of the vector group, and the base vector group is output as the illumination base image group, and

in the step of generating the comparison image, a correspondence between each point of the 3D shape data of the object and a pixel of the image with the object being in an estimation value at current time is obtained by using the 3D shape data of the object, an image illumination base group in which the illumination base image group is projected to the image with the object being in the estimation value is generated by using the correspondence, and an image nearest to the input image is generated as the comparison image by

linear connection of the image illumination base group.

21. An estimation method of estimating an object state according to claim 12, characterized in that in the step of calculating the correction amount, a 3D motion of the object which causes a moving amount of an object part corresponding to each sub-region in the comparison image to be near to an image displacement distribution is calculated as the correction amount by using the 3D shape data of the object and the image displacement distribution representing the positional relationship between the comparison image and the input image for each sub-region.

22. An estimation method of estimating an object state according to claim 12, characterized by further comprising the step of extracting an image feature amount of each of the comparison image and input image on the basis of luminance values of the comparison image and input image,

wherein in the step of detecting the positional relationship, the positional relationship between the input image and the comparison image for each sub-region is detected on the basis of the image feature amount.

23. An estimation program for estimating an object state, which causes a computer to execute the steps of:

inputting an input image containing an object

whose state is to be estimated, the state being at least one of a position and posture;

generating, as a comparison image, an image containing the object in a predetermined state by using 3D shape data of the object;

detecting a positional relationship between the comparison image and the input image for each sub-region having a predetermined size in the image;

calculating a correction amount of the object state in the comparison image by using the detected positional relationship; and

correcting the object state set in comparison image generation by using the calculated correction amount, thereby calculating a new object state.

24. An estimation program for estimating an object state according to claim 23, which causes the computer to further execute the steps of:

determining on the basis of the calculated correction amount whether the object state set in comparison image generation is appropriate;

outputting the object state set in comparison image generation as an estimation value when it is determined that the object state is appropriate; and

executing again estimation processing including the step of generating the comparison image, the step of detecting the positional relationship, and the step of calculating the correction amount by setting

the calculated new object state to the predetermined state when it is determined that the object state is not appropriate.

25. An estimation program for estimating an object state according to claim 24, which causes the computer to execute, as the determination step, the step of determining that the object state is appropriate when the correction amount is smaller than a predetermined amount, and determining that the object state is not appropriate when the correction amount is not smaller than the predetermined amount.

26. An estimation program for estimating an object state according to claim 24, which causes the computer to further execute:

the step of calculating a first similarity between the comparison image and the input image after the estimation processing is executed again;

the step of calculating a second similarity between the comparison image and the input image before the estimation processing is executed again; and

as the determination step, the step of comparing the first similarity with the second similarity, determining that the object state is not appropriate when the first similarity is higher than the second similarity, and determining that the object state is appropriate when the first similarity is not higher than the second similarity.

27. An estimation program for estimating an object state according to claim 23, which causes the computer to execute:

as the step of inputting the image, the step of inputting a moving image containing an object; and

as the step of detecting the positional relationship, the step of using a latest frame image of the moving image as the input image.

28. An estimation program for estimating an object state according to claim 23, which causes the computer to execute, in the step of generating the comparison image, the steps of:

reproducing a luminance value of an object surface, which changes depending on an illumination condition; and

generating the comparison image under an illumination condition close to that for the input image by using the reproduced luminance value.

29. An estimation program for estimating an object state according to claim 28, which causes the computer to execute, as the step of generating the comparison image, the step of reproducing the luminance value of the object surface by using an illumination base image group representing a variation in luminance of the object surface depending on the illumination condition.

30. An estimation program for estimating an

object state according to claim 29, which causes the computer to further execute the steps of:

measuring the 3D shape data of the object and reflectance data of the object surface; and

calculating an illumination base image representing the variation in luminance of the object surface depending on the illumination condition by using the 3D shape data and the reflectance data of the object surface.

31. An estimation program for estimating an object state according to claim 30, which causes the computer to execute:

as the step of calculating the illumination base image, the step of calculating a vector group representing the luminance value of each point of the 3D shape data under a plurality of illumination conditions, obtaining a base vector group in descending order of eigenvalues by principal component analysis of the vector group, and outputting the base vector group as the illumination base image group, and

as the step of generating the comparison image, the step of obtaining a correspondence between each point of the 3D shape data of the object and a pixel of the image with the object being in an estimation value at current time by using the 3D shape data of the object, generating an image illumination base group in which the illumination base image group is

projected to the image with the object being in the estimation value by using the correspondence, and generating, as the comparison image, an image nearest to the input image by linear connection of the image illumination base group.

32. An estimation program for estimating an object state according to claim 23, which causes the computer to execute, as the step of calculating the correction amount, the step of calculating, as the correction amount, a 3D motion of the object which causes a moving amount of an object part corresponding to each sub-region in the comparison image to be near to an image displacement distribution by using the 3D shape data of the object and the image displacement distribution representing the positional relationship between the comparison image and the input image for each sub-region.

33. An estimation program for estimating an object state according to claim 23, which causes the computer to further execute:

the step of extracting an image feature amount of each of the comparison image and input image on the basis of luminance values of the comparison image and input image; and

as the step of detecting the positional relationship, the step of detecting the positional relationship between the input image and the comparison

image for each sub-region on the basis of the image feature amount.